



Early growth response of *Acacia modesta* seedlings as influenced by magnetic field (MF)

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ABSTRACT

Excessive use of fertilizers and chemicals (pesticides), exerting a negative impact on the society's economic development because of increase in environmental pollution. Therefore, scientist and researchers are interested to replace it by some biological procedures

such as magnetic field application to ensure the safe and sound health of the society and to improve the productivity with a sustainable farming system. The study was designed to check the growth potential of *Acacia modesta* (phulahi) in response to MF application as pre-sowing seed treatment. Seeds of *Acacia modesta* was treated with magnetic field of 75 mT for 0 minutes (T_1) non-treated seeds, 5 (T_2), 10 (T_3), 15 (T_4), 20 (T_5), 25 (T_6) and 30 (T_7) minutes. Highest mean values for all parameters i.e. collar diameter (1.64 mm), shoot length (18.7 cm), no of branches (7.33), no of leaves (22.5), root length (14.6 cm), fresh weight of seedlings (2.93 g), and dry weight of seedlings (1.10 g) were observed for the treatment (T_3), as compared to all other treatments. The net percentage increase in all parameters was higher in (T_3) i.e. collar diameter (57.63%), shoot length (15%), number of branches (100%) number of leaves (96%), root length (29%), fresh weight of seedlings (36.76%), and dry weight of seedlings (57.76%), when compared to controlled (T_1) and other MF exposed treatments. The results clearly indicated that *Acacia modesta* seedlings showed the best results on their exposure to MF of 75 mT for 15 minutes as compared to all other treatments.

Keywords: *Acacia modesta*, magnetic field, seed treatment, germination potential, seedlings.

1. INTRODUCTION

Pro-ecological treatments such as ionizing, use of laser, radiation, electric or magnetic technology in the field of agriculture and forestry is getting popularity day by day because of the persistent environmental pollution in today's world. Application of biophysical methods on plants to study the influence of such physical factors on plants is the main consideration of many scientists throughout the world (Faqenabi *et al.*, 2009).

Electric field application results in morphological and physiological changes in plants. Scientists determined that low-frequency MF application increased SGP. Pre-Sowing seed treatment (PSST) of low-viability rice with MF resulted in great SGP and seedling vigor (Carbonell *et al.*, 2000). In this regard, pre-sowing seed treatment with magnetic field (MF) is safe and reasonable physical way to increase the seedling growth and germination of seed because it improves the concentration of ions, free radicals and electrical charges resultantly makes the membranes of seeds more permeable without altering the chemical profile of seed. Free movement of ions activates the metabolic pathways by enhancing the biochemical and physiological feedback (Iqbal *et al.*, 2012; Muhammad Arshad Ullah *et al.* 2017).

Pakistan has an area of 79.6 million hectares, out of which 4.8% is under forests, whereas it should be at least 20-25% (Quraishi, 2005). Progress in forestry and its sustainable management is necessary for stable and continual progress and growth in numerous areas such as farming, industry, education, health, and defense. Innumerable industrial along with fire wood, timber wood, pulp, paper and paper products are the urgent needs of Pakistan (Quraishi, 2003). Pakistan is spending a huge stake of foreign exchange (Rs 20 billion/ annum) to import 16 million m³ wood and wood products in order to meet the increasing ultimatum for timber and fuel wood (FAO, 2010). To spend such a large amount of money on the import of wood and wood products is not very wise for developing countries like Pakistan. So for achieving economic and ecological stability, it is need of the time to adopt new techniques that may be more ecologically friendly and economically reasonable.

The natural way is considered as one of the safest and permanent solution to solve a problem. Earlier studies showed that all living things are influenced by earth magnetic force (Ahmet, 2003). Several scientists have reported the magnetic field influence on non-woody plants like wheat (Hozayn *et al.*, 2010), mung bean (chen *et al.*, 2012) and strawberry (Ahmet, 2003). Regarding woody plants a little research work has been done all over the world. Tanvir *et al.* (2012) conducted a research to explore the growth potential of *Albizia procera* and *Leucaena leucocephala* as influenced by MF. They concluded that the low intensity MF significantly influenced plant growth. Tanvir *et al.* (2012) in their study strongly suggested that similar type research should be extended by including some other tree species and by using different magnitude levels of magnetic fields. They also reported that PSST of MF resulted in biological changes going on in the plants, such as various root-growth forms, growth rate, reproduction and growth of the meristem cells, and chlorophyll a and b quantities. Keeping in view the above discussion the present study was designed to check the growth potential of *A. modesta* (Phulai) in response to MF application as pre-sowing seed treatment.

A. modesta belongs to family Fabaceae, commonly known as Phulahi and locally called palosa. It is a medium-sized tree that grows on stony grounds and native to Afghanistan, India and Pakistan including Punjab, NWFP, and Baluchistan (Baquar, 1989). In Pakistan, it is found at an elevation of 1200 m in the foothill ranges of the Himalayas, Salt Range, Sulaiman Hills, Baluchistan and Kirthar Range. It is also found in the plains close to these mountains (Sheikh, 1992). Various parts of *A. modesta* such as gum, leaves, flowers, sticks, and wood are used for several medicinal purposes (Atta-ur-Rahman *et al.*, 1986; Nadkarni, 1976).

In drylands, *A.modesta* is an important forage species. Tender leaves and twigs in particular have a high nutritional value and palatability, and are used as fodder for goats and camels. With around 16% protein levels, young shoots are typically used to supplement grass during the dry season. For livestock, this mixture is ideal to improve nutrient utilization and increase weight gain (ICARDA). It is a browse shrub liked by all kind of animals including camels. Its thorns are providing good protection when planted as hedge. It also produces good quality fuel wood (Baquar, 1989). Because of the above mentioned unique properties and multiple uses, researchers are interested to investigate the performance of tree species as prejudiced by MF as PSST. The main objective of this study is to assess the growth potential of the above mentioned highly demanded forage species as influenced by MF.

2. MATERIALS AND METHODS

The proposed research work was started during the year 2013. Response of *A.modestato* MF application as pre-sowing seed treatment (PSST) was studied. Healthy, well ripened and uniform sized seeds of *A. modesta* were obtained from Punjab Forestry Research Institute (PFRI), Gatwala, Pakistan. The seeds were cleaned to make them free from debris. Potting medium was prepared with sandy loam soil (taken from the upper 10 cm layer of soil in the Forest Nursery, Department of Forestry, Range Management and Wildlife, University of Agriculture, Faisalabad, Pakistan) made free from plant debris/straw and other deleterious materials, sun dried, grounded and passed through 5.0 mm strainer. Desired numbers of polythene bags (PBs) of dimensions 10 × 12 cm were filled with soil material as per experimental plan. However six numbers of PBs filled with soil were reserved for rising of experimental plants per treatment. Total number of seeds of *Acacia* species under seven treatments with six replications were = (Number of seeds per treatment (n) × T × R = 4 × 7 × 6 = 168). Where, T stands for number of treatment and R for number of replication. The pre sowing magnetic treatments were administrated using an electromagnet device (Magnetic Seed Stimulator).

The soaked seeds were taken to the Bio-magnetic Lab, Department of Physics, University of Agriculture Faisalabad and were grouped into seven categories to treat them with MF of 75 mT for time exposure of 5 minutes (T_2), 10 minutes (T_3), 15 minutes (T_4), 20 minutes (T_5), 25 minutes (T_6) and 30 minutes (T_7). Non-treated were taken as control (T_1). The seeds were placed in a petri dish on the pole of electromagnet. The above mentioned seeds of 7 groups were sown in the assigned PBs within no time to avoid the drying of absorbed seeds. Four (4) numbers of seeds of each species were put in the assigned PBs. Number of new seedling emerging from the seeds were recorded on daily base till complete germination. The experimental seeds were regularly monitored for their germination and a standard procedure was followed to collect the data for growth parameters like collar diameter, shoot length, root length, no of leaves, no of branches, fresh weight and dry weight of seedlings to assess the growth potential of *A. modesta* as influenced by MF (Tanvir *et al.*, 2014).

Finally, data for all the parameters (mentioned) except root length, fresh weight and dry weight was recorded before harvesting. The plants were harvested after ninety days of sowing. The uprooted plants were thoroughly washed up with tap water first and with distilled water finally. The harvested plants were cut into two pieces i.e. the root and the shoot; both root length (RL) and shoot length (SL) for all plants were measured. The data was subjected to analysis of variance (ANOVA) techniques with completely randomized design (CRD) followed by mean comparison by applying (LSD) to determine the level of significance among means of all treatments. The result helped the researchers to assess the growth behavior of the above mentioned highly demanded forage species in response to PSST of MF.

3. RESULTS AND DISCUSSIONS

Effect of MF on collar diameter (CD)

Data analysis revealed that different seedlings of *A.modesta* performed differently with regard to collar diameter as influenced by magnetic field (MF). CD of the seedlings treated with MF as pre-sowing seed treatment (PSST) was significantly different from the seedlings of controlled one (T_1).

Table 1 clearly depicts that the MF application of 75 mT for T_3 (10 minutes) resulted in maximum increase in CD with mean value 1.64 mm followed by the seedlings of T_2 (5 minutes) with collar diameter of 1.38 mm, T_5 (20 minutes) 1.36 mm, T_4 (15 minutes) 1.34 mm, T_6 (25 minutes)1.33 mm and T_7 (30 minutes) 1.30 mm. The minimum value 1.04 mm was observed for the seedlings of T_1 (controlled). Figure 1 shows the percent increase in CD of *A. modesta* plants treated with MF for different times of intervals in decreasing order were T_3 (57.63%) > T_2 (32.94%) > T_5 (30.83%) > T_4 (30.6%) > T_6 (27.8%) > T_7 (25%) > T_1 (0%). Convincingly, seedlings from treated seeds in all treatments resulted differently showing greater plant CD than control. However, application of MF of 75 mT for 5 minutes or above showed maximum CD of *A. modesta* seedlings as compared to non-treated seedlings. Shabrangi and Majd, (2009) described increase in CD, under the effect of MF while working on several monocot and dicot plants. Racuciu (2011), working on *Zea mays* explained the stimulatory influence of very low MF level which subsequently results in increased CD. Various characteristics of the plants effected by MF i.e. growth of seedlings, increase in meristematic cells and

chlorophyll a and b result in increase of stem diameter with increase in meristematic tissue growth of the plants (Namba *et al.*, 1995; Atak *et al.*, 1997 and Reina *et al.*, 2001).

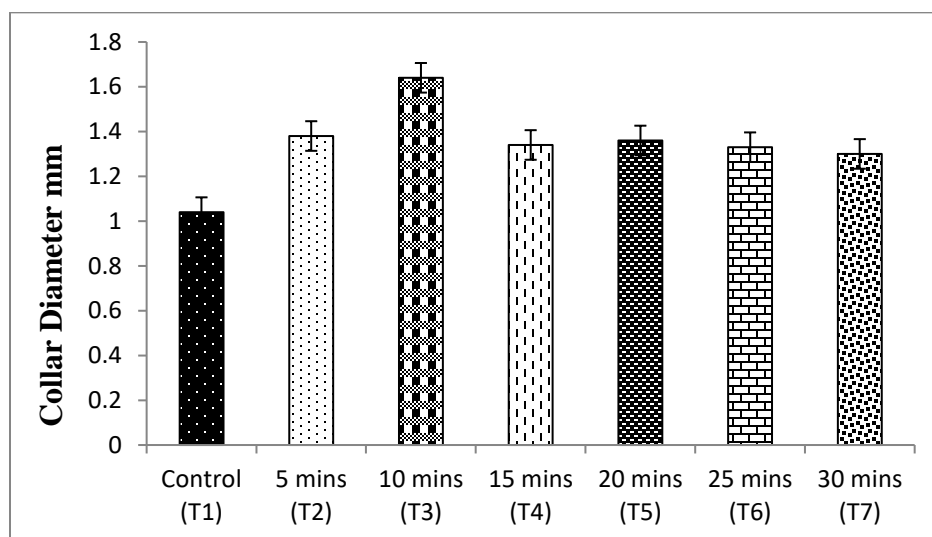


Figure 1 Effect of Magnetic field on collar diameter of *Acacia modesta*

Table 1

Mean value of various parameters of *Acacia modesta* along with their level of significance, standard error and coefficient of variance (CV %) as influenced by magnetic field.

Effect of MF on shoot length (SL)

Sr.No.	Parameters	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	Standard error	LSD	CV%
1	Collar Diameter	1.04	1.38	1.64	1.34	1.36	1.33	1.30	0.78	0.159	10.10
2	Shoot Length	16.3	17.1	18.7	17.4	17.8	17.6	17.6	0.38	0.778	3.79
3	No. of Branches	3.66	6.33	7.33	7.17	5.16	5.00	4.50	0.44	0.912	13.90
4	No. of Leaves	11.5	16.0	22.5	17.5	15.5	13.5	13.5	1.44	2.932	15.77
5	Root Length	11.3	11.4	14.6	13.8	12.9	12.1	12.1	0.48	0.988	11.29
6	Fresh Weight	2.15	2.46	2.93	2.43	2.40	2.34	2.31	0.131	0.266	8.96
7	Dry Weight	0.70	0.81	1.10	0.90	0.81	0.75	0.72	0.062	0.126	11.42

The plants having healthy and long shoot length are considered as more vigorous and healthy while plants having weak and smaller plant height are considered less vigorous and under stress (Hartman *et al.*, 1988; Ahmad Raza *et al.* 2017). Results indicated that different seedlings executed contrarily with respect to shoot length (SL) as influenced by magnetic field (MF). SL in the seedlings of *A.modesta* of all treatments treated with MF was significantly different from the seedlings of controlled one (16.3 cm) as depicted in Table 1. The maximum mean value of shoot length was 18.7 noted in the plants treated under T₃ (10 minutes), followed

by T_5 (17.8 cm). Whereas seedlings treated for 25 and 30 minutes i.e. T_6 and T_7 showed similar values of SL (17.6 cm), followed by T_4 and T_2 (17.4 cm) & (17.05 cm) respectively (Figure 2). The SL in the seedlings of T_4 , T_6 and T_7 were statistically same but lesser than the SL of T_3 seedlings. This suggested that further increase in time could not enhance SL.

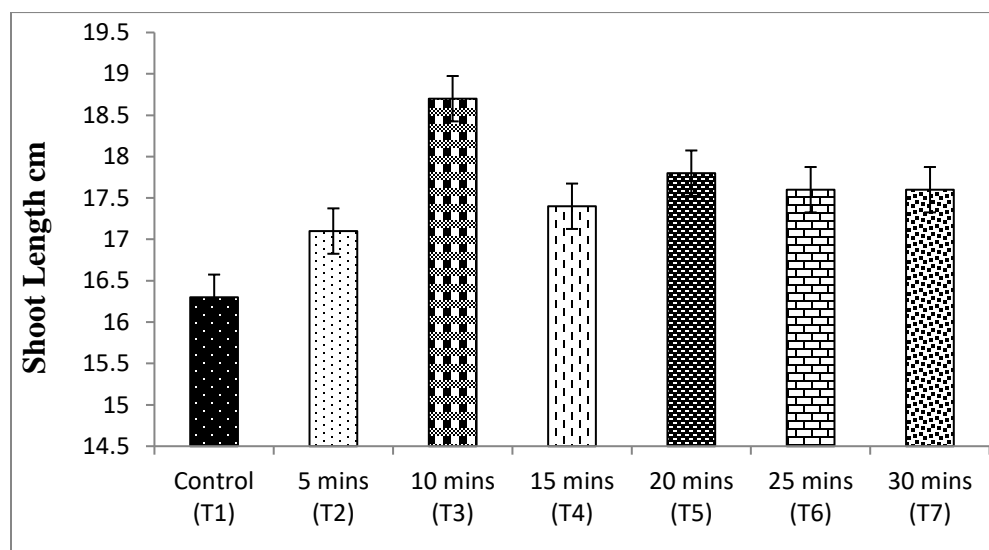


Figure 2 Effect of Magnetic field on shoot length of *Acacia modesta*

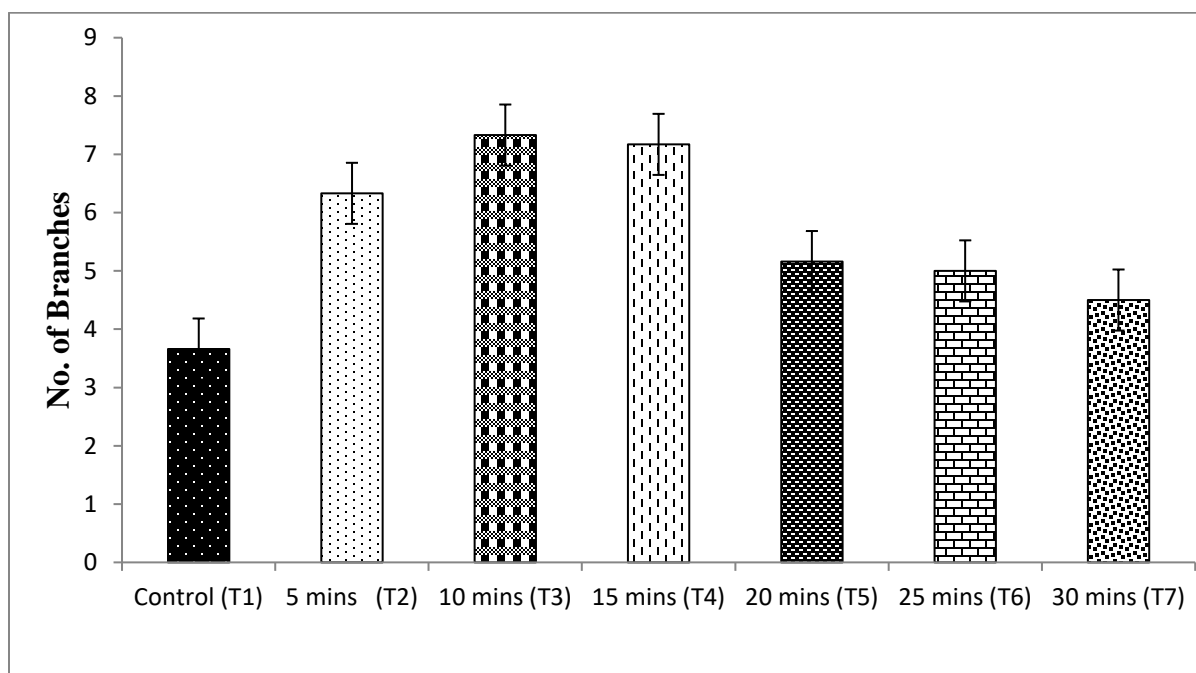


Figure 3 Effect of Magnetic field on no. of branches of *Acacia modesta*

Therefore, treatment of T_2 seedlings was found best suited to get enhanced SL in *A.modesta*. As for the percent increase in *A.modesta* SL T_3 increased 15% more than the controlled i.e. T_1 . The values of percent increase in shoot length of the plants treated with magnetic flux for different times of exposure in decreasing order were; T_3 (15%) > T_5 (9.2%) > T_6 & T_7 (8%) > T_4 (6.7%) > T_2 (4.02%) > T_1 (0%). Audus (1960) noticed strong magneto-tropic affection on shoot development. He detected that the effect of the MF on the seeds increased their growth, activated protein formation resulting in higher plant growth. A strong positive magnetic effect on shoot development in plants was also reported by Pietruszewski (1999) and Penuelas *et al.* (2004). Tanvir *et al.* (2012);

Smith *et al.* (1992) studied that application of MF resulted in increase of various characteristic of the plants like shoot growth, reproduction and chlorophyll quantities. Our findings were also similar to that of Iqbal *et al.* (2012) who noticed that the phloem and xylem vessels developed more and parenchyma cells were found larger than controlled. They have also reported increment in shoot length and shoot weight.

Effect of MF on number of branches

No. of branches in the seedlings of *A.modesta* under various treatments of MF were significantly different from the seedlings of controlled one as indicated by Table 1. Results indicated that the maximum number of branches (7.33) that in the seedlings of *A. modesta* were record in the T₃ treatment of MF 75 mT for 10 minutes only. In the rest of treatments such as T₂(6.33), T₄(7.17), T₅ (5.16), T₆(5.00) and T₇(4.50) which were treated for 5, 15, 20, 25 and 30 minutes respectively (Figure 3), the number of branches reduced in accordance of increasing of time interval for treating seeds. Though, number of branches of all treatment seedlings was significant than the seedlings of controlled seeds. When we talk about the percent increase in number of branches in *A. modesta* in comparison with T₁ (controlled). Seedlings of T₃ (10 minutes) showed 100 % increase by T₄ (15minutes) which attained 95% increase followed by T₂ (5 minutes) which exhibited 72% increase followed by T₅(20 minutes) which presented 40% increase followed by T₆ (25 minutes) which attained 36% increase and T₇ (30 minutes) showed 22% increase as seedlings of non-treated seeds .

Several researchers like Pietruszewski (1996), Kumar *et al.* (2004), Shabrangi and Majde, (2009) reported increase in branch length and number of branches of the plants treated with magnetic field effect (MF). They stated noticeable increase in physical growth i.e. root-shoot diameter, number of branches, number of leaves etc.

Effect of MF on number of leaves

Leaves are the most imperative part of the plant body. These are the responsible for all the vital reactions taking part inside the plant i.e. photosynthesis, carbon cycle, Krebs cycle etc. the large number of leaves on a plant indicates its good health and bumper growth. Number of leaves in the seedlings of *A.modesta* under various treatments of MF was significantly different from the seedlings of controlled one. It is clear from the Table 1 that mean value of number of leaves in the seedlings of *A.modesta* i.e.T₁ (controlled) was 11.5. The maximum mean value of number of leaves was 22.5 that was noted in the plants treated under T₃ (10 minutes) T₄ (17.5 cm) > T₂ (16 cm) > T₅ (15.5 cm) > T₆ = T₇ (13.5 cm), > T₁ (11.5 cm); (Figure 4). Regarding the percent increase or decrease in number of leaves are concerned in *A. modesta* seedlings of T₃and T₄ had more number of leaves by 96% and 52% more than the controlled seedlings i.e. T₁, respectively.

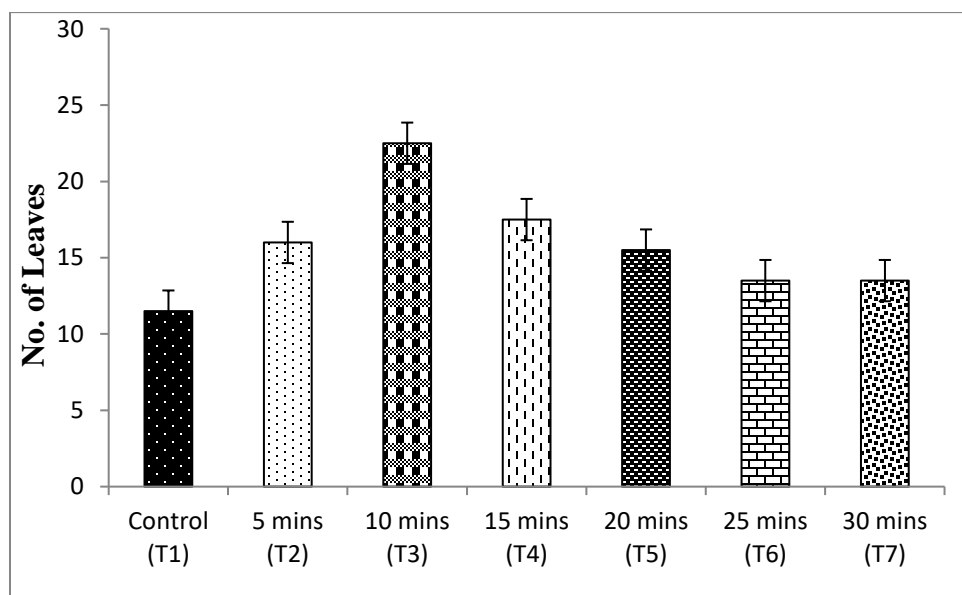


Figure 4 Effect of Magnetic field on no. of leaves of *Acacia modesta*

The values of percent increase in number of leaves per plant treated with magnetic flux for different times of exposure in decreasing order were T₃ (96%) > T₄ (52%) > T₂ (47%) > T₄ (34%) > T₆=T₇ (17%) > T₁ (0%). The application of 75 mT MF as pre-sowing seed treatment (PSST) for different time intervals showed significant results as discussed above. In *Acacia modesta* we

observed 96% more number of leaves as compared to the controlled one. Our results also favor the initiative that has been also formerly studied by Socorro *et al.* (1999), Jovanic and Sarvan (2004) and Racuciu *et al.* (2006). They described a promising effect of MF treatment on leaf thickness in plants, leading to increase in the thickness of spongy tissues and in the length and the width of the chlorophyll containing pigments. The above mentioned scientists had studied the morphological behavior of magnetic field on leaves, also but we had only quantitative study. Alikamanuglo *et al.* (2007) discovered that magnetic field (MF) has a positive effect on plant fresh weight, leaf number and chlorophyll amount. The MF has positive effect on the leaf emergence and gain in body weight of the plant as compared to the gamma radiations applied.

Effect of MF on root length (RL)

Roots not only anchor the plants with soil but also help them in nutrient and water uptake from deeper soil horizons (Quraishi, 2005). Different seedlings of *A. modesta* performed differently with regard to Root length as influenced by magnetic field (MF). Table 1 clearly depicts that Root length in the seedlings of *A. modesta* under various treatments of MF were significantly different from the seedlings of controlled one i.e. T₁ (11.3 cm).

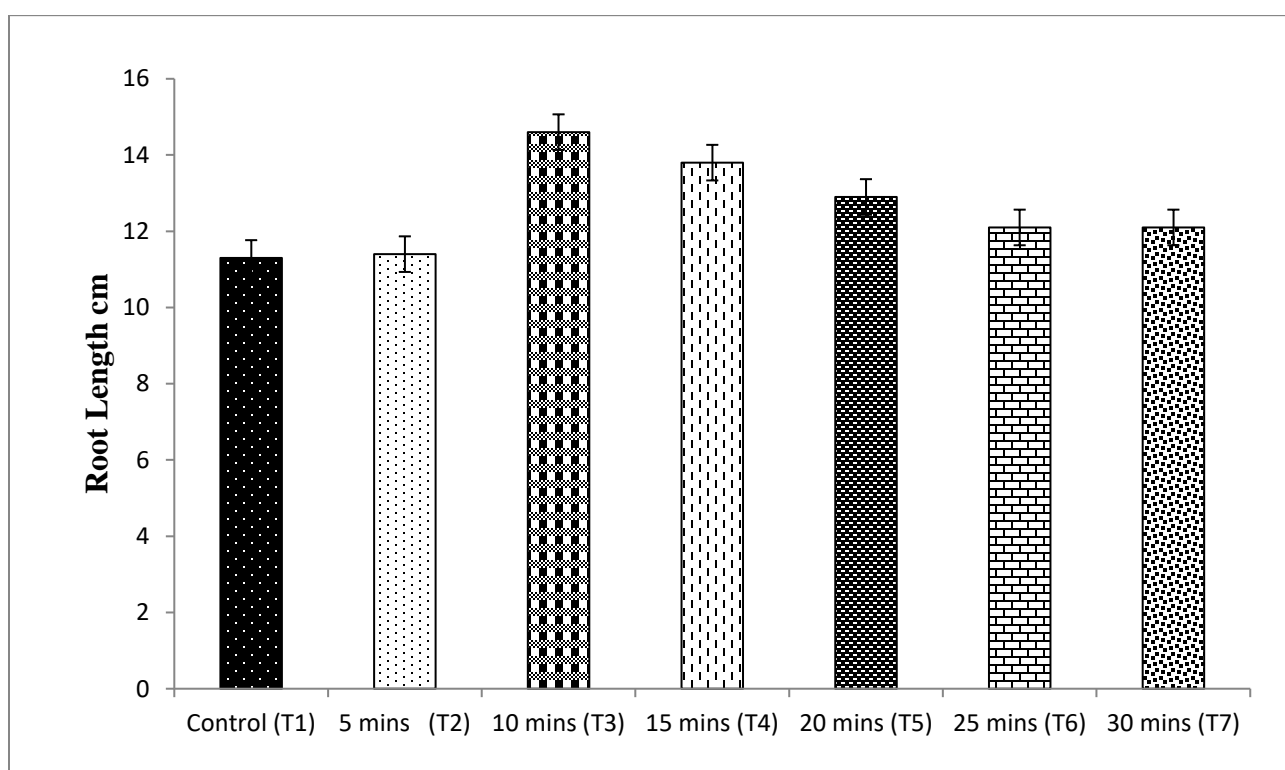


Figure 5 Effect of Magnetic field on root length of *Acacia modesta*

The maximum mean value (14.6 cm) of Root length was noted in the plants treated under T₃ (10 minutes) followed by T₄ (13.8), T₅ (12.9 cm), T₆ (12.1cm)= T₇ (12.1 cm), T₂ (11.4 cm) and T₁ (11.3 cm); (Figure 5). As for the percent increase in *A.modesta* root length T₃ increased 29 % more than the controlled i.e. T₁.The values of percent increase in root length of the plants treated with magnetic flux for different times of exposure in decreasing order were T₃ (29%) > T₄ (22%) >T₅ (13.2%) >T₆ =T₇(7.4%) > T₂ (1%) > T₁ (0%). Audus (1960) noticed strong magneto-tropic affection on shoot development. He detected that the effect of the MF on the seeds increased their growth, activated protein formation resulting in higher plant growth. Roots seem less susceptible to the magnetic field than shoots and show less growth as compared with shoots (Kato, 1988; Kato *et al.*, 1989). Our study narrates the same idea as our maximum RL for *A. modesta* was 14.6 cm in T₃ while, our shoot length (SL) for same treatments was 18.7 cm. A strong positive magnetic effect on root development in plants was also reported by Arababian *et al.* (2004). Smith *et al.* (1992) studied that application of MF resulted in increase of various characteristic of the plants like root growth and reproduction.

Effect of MF on fresh weight (FW)

In *A.modesta* among all the seed treatments with magnetic field of 75 mT for 10 minutes (T_2) resulted in the fresh weight of 2.93g that was maximum mean fresh weight of plant among all the treatments. It was noticed that the increase in time period decreased the net weight. T_4 (15 minutes), T_5 (20 minutes), T_6 (25 minutes), T_7 (30 minutes) showed the decreasing results as compared with the T_3 in comparison with T_1 (controlled) as described in Table 1 & Figure 6. The mean fresh weight of all the plants of *A. modesta* were as $T_3(2.93\text{ g}) > T_2(2.46\text{ g}) > T_4(2.43\text{ g}) > T_5(2.40\text{ g}) > T_6(2.34\text{ g}) > T_7(2.31\text{ g}) > T_1(2.15\text{ g})$. The values of percent increase in fresh weight of plant treated with magnetic flux for different times of exposure in decreasing order were $T_3(36.76\%) > T_2(15\%) > T_4(13\%) > T_5(10\%) > T_6(7\%) > T_7(5\%) > T_1(0\%)$. Our study narrates similarity with the findings of (Alikamanoglu *et al.*, 2007; Pietruszewski, 1996), Racuciu (2011) that when cell division and protein synthesis in any plant increases it results in increased fresh weight. In cellular level studies have shown that RNA and protein synthesis on G1 phase are affected by magnetic field strength changes and cell division rate increases for cells exposed to magnetic field, which results an increase in plant fresh weight. Nasher (2008) and Hozayn and Qados (2010) worked on the application of magnetized water instead of magnetized seed.

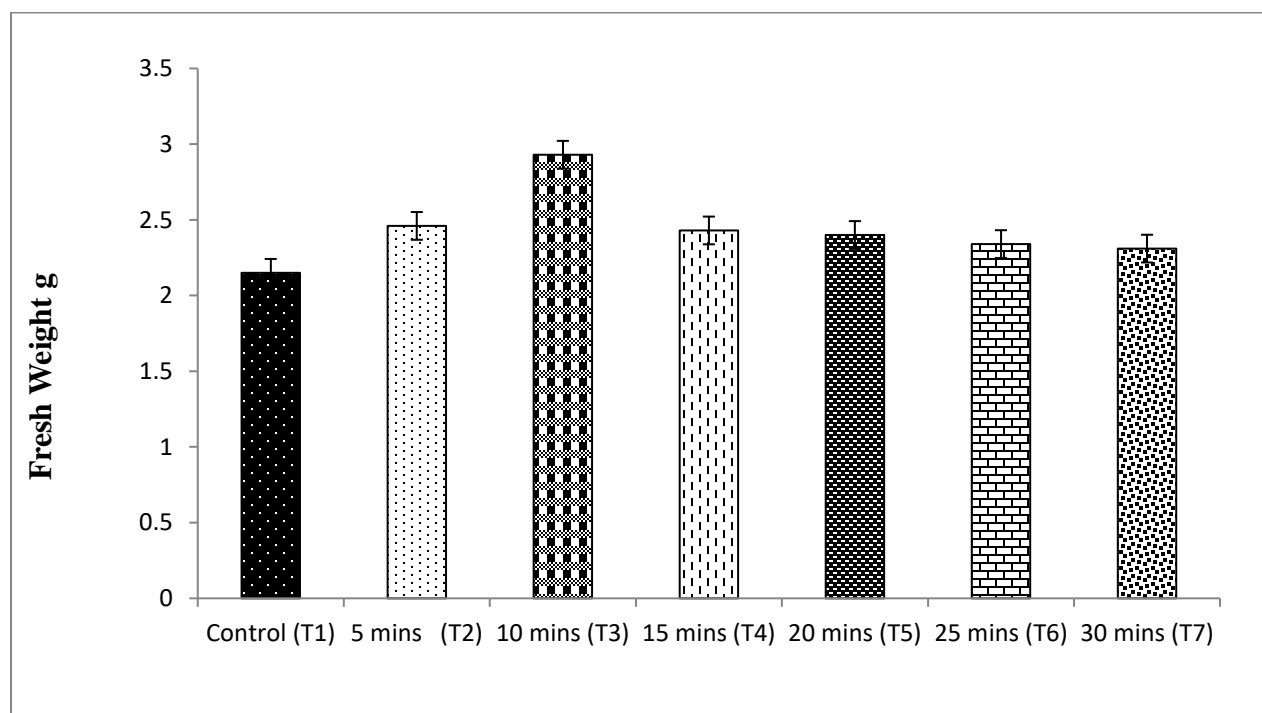


Figure 6 Effect of Magnetic field on fresh weight of *Acacia modesta*

It increased the plant growth, yield and fresh weight. They reported that the researchers have shown that magnetic field changed the characteristics of cell membrane, effected the cell reproduction and caused some changes in cell metabolism resulted in increased plant fresh and dry weight. As reported by the above mentioned research study also describes that magnetic field has positive effect on the fresh weight. We found 36% more fresh weight as compared with the controlled seedlings of *A.modesta*.

Effect of MF on dry weight (DW)

Table 1 clearly depicts that dry weight (s) in the seedlings of *A.modesta* under various treatments of MF were significantly different from the seedlings of controlled one. It is clear from the data that mean value of dry weight in the seedlings of *A.modesta* i.e. T_1 (controlled) was (.7g). There was gradual increase in the dry weight of the plants as the time period for the PSST was increased but there was no significant increase after 10 minutes i.e. T_3 (Figure 7). The maximum mean value of dry weight was 1.1 g that was noted in the plants treated under T_3 (10 minutes) followed by dry weight (s) in the seedlings T_3 (1.1 g), T_4 (0.90 g), $T_2=T_5$ (0.81 g), (0.95 g), T_6 (0.75 g), T_7 (0.72 g).

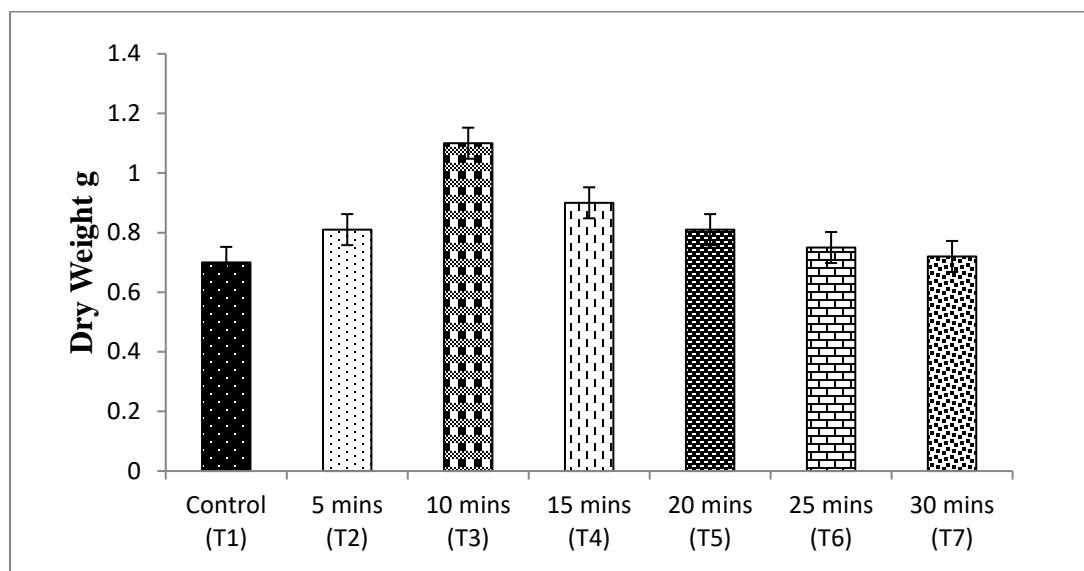


Figure 7 Effect of Magnetic field on dry weight of *Acacia modesta*

Regarding percent increase in dry weight of *A. modesta* plants treated with magnetic flux for different times of exposure in decreasing order were T_3 (57.76%) > T_4 (29%) > $T_2 = T_5$ (16%) > T_6 (12%) > T_7 (10%) > T_1 (0%). Yanan *et al.* (2005) reported that MF-pre-sowing handling increased seed germination rate, plant weight, sapling growth and progress, although also increased lipid oxidation and ascorbic acid insides. Nasher (2008), Ijaz *et al.* (2012) and Iqbal *et al.* (2012) reported a linear increase in saplings dry weight with the increase in magnetic field (MF). The maximum dry weight was perceived at the highest level of MF.

4. CONCLUSION

According to above mentioned results, the growth of all parameters increased up to T_3 i.e. seeds treated with MF for 10 minutes and then it started decreasing as the time interval increased. Conclusively, we can say that *A. modesta* seeds showed best results when treated with magnetic field for 10 minutes. Keeping in view the above study, similar research work should be carried out on other tree species along with their physiological study with different magnitudes of magnetic field (MF) or different time intervals.

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